504

VOLUME 80 SEPARATE No. 504

PROCEEDINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS

SEPTEMBER, 1954

DISCUSSION OF PROCEEDINGS - SEPARATES

165, 259, 318

WATERWAYS DIVISION

Copyright 1954 by the AMERICAN SOCIETY OF CIVIL ENGINEERS
Printed in the United States of America

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

Current discussion of papers sponsored by the Waterways Division is presented as follows:

Number		Page
165	Design Curves for Anchored Steel Sheet Piling (Published in January, 1953. Discussion closed)	
	Tschebotarioff, Gregory P.	1
	Boyer, Walter C. and Lummis, Henry M., 111 (Closure).	5
	Corrections for Transactions	8
259	Salt Water Barriers in the San Francisco Bay (Published in August, 1953. Discussion closed)	
	Jarvis, Clarence S.	9
318	Some Economic Aspects of Waterways Projects (Published in October, 1953. Discussion closed)	
	Orr, Duane	13
	Cookingham, L. P.	15
	Marsh, Marvin B.	18
	Stanley, Owen G.	20
	Schull, H. W., Jr.	23
	Magnuson, N. C.	24
	Carr, Braxton B.	25
	Childe, C. E.	26
	Wilson, Francis J. and Graham, N. R.	30
	Hall, Charles L.	31
	Davis, James W.	33
	Faison, Haywood P. (Closure)	34

Reprints from this publication may be made on condition that the full title of paper, name of author, page reference (or paper number), and date of publication by the Society are given.

The Society is not responsible for any statement made or opinion expressed in its publications.

This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-Ninth Street, New York 18, N.Y.

DISCUSSION OF DESIGN CURVES FOR ANCHORED STEEL SHEET PILING PROCEEDINGS-SEPARATE NO. 165

GREGORY P. TSCHEBOTARIOFF,[10] M. ASCE.—The method of design described by the authors under the heading, "Selection of Design Procedure," is identified as

> "* * * the 'free-earth-support method' in which the penetration is obtained by taking moments about the anchor point but without doubling the increment of passive pressure. Under this condition, the driving costs are reduced while the depth of penetration is still adequate."

Messrs. Boyer and Lummis also state that the writer has questioned the practice of doubling the Rankine passive coefficient and termed it "a dangerous oversimplification."

The writer regrets that these words have been removed from their context. The writer's practical conclusions are diametrically opposed to those attributed to him by the authors. The relevant passage is as follows:[6]

> "In recent years there has been a tendency to assume that the passive earth pressure can always be taken as double its conventional value * * * irrespective of the values and of the direction of the angle of wall friction. This tendency appears to have been based on the results of tests performed in 1924 by Professor Franzius at Hannover * * * it is on these tests that Blum based his recommendations to double the passive earth pressure * * * Blum's recommendation that the passive earth pressure be doubled is said to have been made: 'to allow for the additional resistance due to the undisturbed and naturally compact soil into which the sheet piling is driven.' This is a dangerous oversimplification, especially where sands are concerned."

Only the justification for doubling the conventional Rankine passive coefficient was questioned here, since reliance on unspecified properties of undisturbed soil meant that the doubling of the coefficient might be considered justified under almost all field conditions. To show that this was not permissible the writer has stated[6] that "if the wall is pulled out in respect to the soil * * * the value of K' * * * will decrease to less than one third of its original value." Such a condition can arise in the case of a sheet-pile wall driven on the land side of a light relieving platform.[11] For an anchored sheet-pile bulkhead of the type investigated by the authors, however, the writer indicated that the passive earth pressure coefficient K_P (recorded during most of the tests with model flexible bulkheads) was equal to or greater than the value[6] of 12. During several tests,[12] K_P-values varied from 9 to 15. That is, since ϕ was equal to 36°, values of K_P were from 2.3 to 3.9 times higher than the values expected on the basis of the Rankine passive earth pressure coefficient (K' equal to 3.85), which neglected the effect of wall friction. Tests performed in 1953 confirmed the fact that, for the conditions of anchored bulkheads described by the authors,

[10] Prof. of Civ. Eng., Princeton Univ., Princeton, N. J.

[11] "The Effects of Restraining Boundaries on the Passive Resistance of Sand," by Gregory P. Tschebotarioff and Edmund G. Johnson, Princeton University Report, Princeton, N. J., June 1, 1953, Fig. III.

[12] "Final Report—Large Scale Earth Pressure Tests with Model Flexible Bulkheads," by Gregory P. Tschebotarioff, Princeton Univ., Princeton, N. J., January 31, 1949, Figs. 65, 67, 69, 71, 73, 77, 79, 81, 86, and 88.

the doubling of the Rankine coefficient K' is entirely justified.[13] This conclusion is contrary to that reached by the authors.

Messrs. Boyer and Lummis do not explain why the minimum depth of penetration obtained without doubling the increment of passive pressure is considered to be adequate. A similar opinion has been reached by James R. Ayers, M. ASCE, and R. C. Stokes, in a paper discussed by the writer.[14] It was shown that for sand soils this approach can lead to very high (although uneconomical) factors of safety, whereas in the case of clay soils it can lead to dangerously low factors of safety.

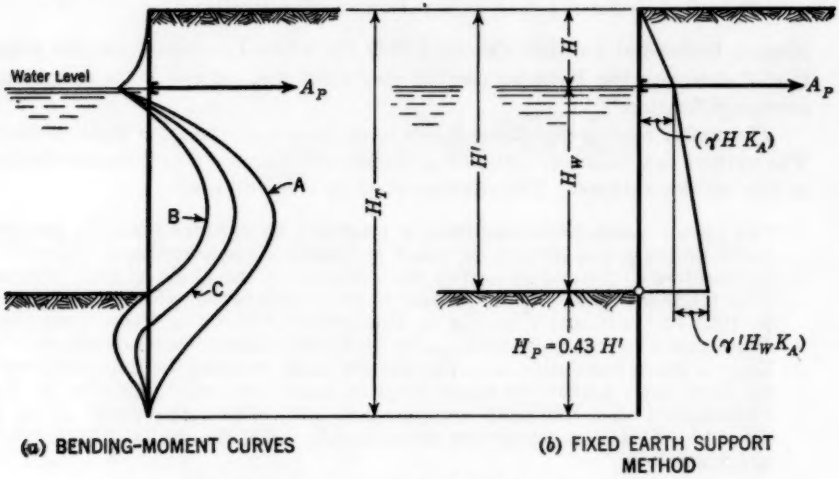

FIG. 6.—COMPARISON OF METHODS OF SHEET-PILE BULKHEAD DESIGN

The design curves developed by the authors are useful for the practical design of very rigid walls in loose sands. For flexible anchored sheet-pile bulkheads in medium to dense sands, however, the design will be uneconomical.

The free-earth-support method, illustrated in Figs. 1 and 2, results in a bending moment diagram similar to curve A in Fig. 6(*a*). Two independent series of model tests performed by the writer[15] and P. W. Rowe[16] have indicated that, for flexible bulkheads in clean medium to dense sands, definite restraint at the point of the piling is present—even at depths of penetration barely sufficient to provide a factor of safety of unity if the effect of wall friction on the passive resistance of the sand is neglected. For the same depth of penetration, the amount of restraint increases with the flexibility of the bulkhead and with the stiffness of the soil.

---

[13] "The Effects of Restraining Boundaries on the Passive Resistance of Sand," by Gregory P. Tschebotarioff and Edmund G. Johnson, Princeton University Report, Princeton, N. J., June 1, 1953, p. VIII.

[14] Discussion by Gregory P. Tschebotarioff of "The Design of Flexible Bulkheads," by James R. Ayers and R. C. Stokes, *Transactions*, ASCE, Vol. 119, 1954, p. 390.

[15] "Final Report—Large Scale Earth Pressure Tests with Model Flexible Bulkheads," by Gregory P. Tschebotarioff, Princeton Univ., Princeton, N. J., January 31, 1949.

[16] "Anchored Sheet-Pile Walls," by P. W. Rowe, *Proceedings*, Inst. of C. E., London, England, Vol. 1, Pt. 1, 1952, p. 27.

Tests have shown that for H_P equal to 0.43 H' the point of contraflexure very closely coincides with the dredge line (curve B, Fig. 6(*a*)).[15] On the basis of these test results, the writer proposed the modified fixed-earth-support method illustrated by Fig. 6(*b*).[17] A hinge is assumed at the dredge line, and bending moments above the dredge are computed for a beam on two supports with an overhanging end. The active earth pressure coefficient K_A was determined from

$$K_A = \left(1 - \frac{H}{f' H'}\right) 0.33 f''' \ldots\ldots\ldots\ldots\ldots\ldots (40)$$

The coefficients f' and f''' were assumed to equal 3.5 and 0.9, respectively.

This design procedure was based on the analysis of the summary of the test results given in Fig. 7, which covers the twelve tests performed with clean

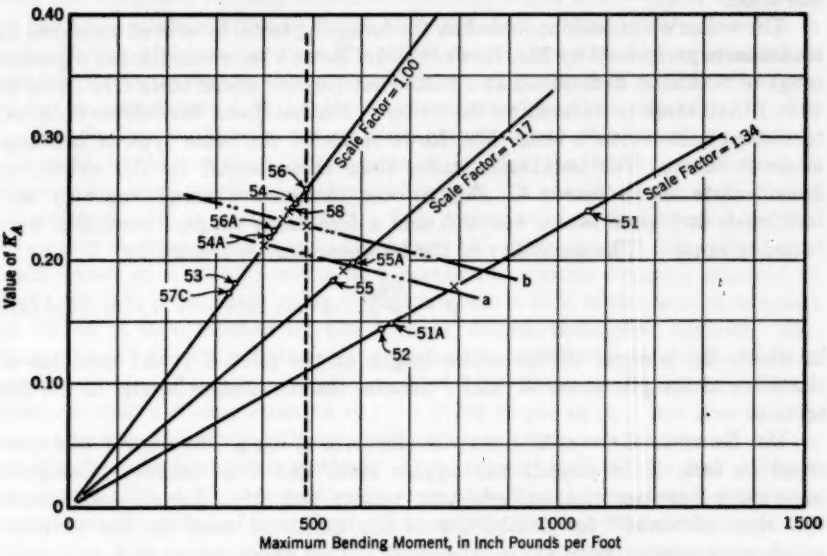

FIG. 7.—BULKHEADS FOUNDED IN CLEAN SANDS

sands.[18] The same model bulkhead (steel plate, $\frac{1}{4}$ in. thick) was used throughout all the tests. The bulkhead's flexibility, however, was varied by changing (to the same scale) the distance H' from the top of the backfill to the dredge line and the distance H from the top of the backfill to the anchor level. The depth of embedment H_P was also varied. The total bulkhead length H_T was varied from a maximum of 98 in. to a minimum of 57 in.

The three lines radiating from the origin in Fig. 7 show the theoretical relationship between various values of the active lateral earth-pressure coefficient K_A, based on intergranular pressures, and the maximum bending moment

[17] "Soil Mechanics, Foundations and Earth Structures," by Gregory P. Tschebotarioff, McGraw-Hill Book Co., Inc., New York, N. Y., 1951, p. 506.

[18] "Final Report—Large Scale Earth Pressure Tests with Model Flexible Bulkheads," by Gregory P. Tschebotarioff, Princeton Univ., Princeton, N. J., January 31, 1949, Fig. 42.

values, computed according to Fig. 6(*b*), for the three scale factors used in a series of tests.[15] By plotting the measured bending-moment values on these lines, the corresponding K_A-values are obtained. It will be noted from Fig. 7 that the values of K_A obtained in this manner decrease with an increasing flexibility as given by the scale factor. The line a–a in Fig. 7 connects the average values of the tests with the same depth of embedment (H_P) equal to 0.63 H' at each of the three scale factors. Points 54 and 54A show that the procedure suggested by Fig. 6(*b*) is valid for a depth of embedment of H_P equal to or greater than 0.43 H'. It should be noted that model similarity was based on the similarity of both dimensions and stresses and was shown to exist for bending moments not exceeding the value of 490 in. lb per ft.[19] This value is indicated by a vertical dashed line in Fig. 7. Eq. 40 is based on a value of K_A equal to 0.23 that was the intersection of the dashed line with the line b–b.[20]

The writer's conclusions (based on the foregoing tests) have been amplified by model tests performed by Mr. Rowe.[16] Mr. Rowe's tests constituted a greater range of bulkhead flexibilities at a somewhat smaller model scale (H_T equal to 42 in.) than those performed by the writer. For bulkhead flexibilities identical to those of the writer's tests, Mr. Rowe recorded the same type of bending-moment curve. For bulkheads stiffer than those tested by the writer, an intermediate curve (curve C, Fig. 6) was obtained whereas, for very stiff bulkheads and loose sands, curve A and a free earth support condition were found to apply. The flexibility of the bulkhead was expressed by

$$\rho = \frac{H^4_T}{E\,I} \qquad (41)$$

in which H_T is equal to the entire length of the pile; E is the modulus of elasticity of the pile material; and I denotes the moment of inertia of the pile section.

Mr. Rowe used the coefficient ρ in the form of log ρ, whereby H was measured in feet, E in pounds per square inch, and I in inches^4. Complete agreement between the writer's test results and Mr. Rowe's test results was then obtained[21] for flexibilities of the bulkhead used by the writer—which were greater than log $\rho = -2.97$. This value corresponds to ρ equal to 22.5 sq in. per lb. (It should be noted that ρ has dimensions that are equal to the reciprocal of stress; Mr. Rowe's procedure of determining model similarity is thus fundamentally similar to the writer's method.)[22]

In contrast to the procedure illustrated in Fig. 6(*b*), based on the fixed-earth-support method and a hinge at the dredge line, Mr. Rowe began from the opposite possible limit condition and based his design on the assumption of free earth support. The maximum moment of curve A (Fig. 6(*a*)) was then reduced by an empirical coefficient.[21]

---

[19] "Final Report—Large Scale Earth Pressure Tests with Model Flexible Bulkheads," by Gregory P. Tschebotarioff, Princeton Univ., Princeton, N. J., January 31, 1949, p. 40.

[20] *Ibid.*, p. 70.

[21] "Anchored Sheet-Pile Walls," by P. W. Rowe, *Proceedings*, Inst. of C. E., London, England, Vol. 1, Pt. 1, 1952, p. 45, Fig. 14.

[22] Correspondence by G. P. Tschebotarioff on "Anchored Sheet-Pile Walls," by P. W. Rowe, *Proceedings*, Inst. of C. E., London, England, Vol. 1, Pt. 1, 1952, p. 616.

A detailed comparison of the two methods of design will not be undertaken at this time; both have advantages and limitations. It should be noted that it would be erroneous to consider Mr. Rowe's method a free-earth-support method in the same sense that this term applies to the design curves presented by the authors. The bending moments computed according to all free-earth-support methods, including the one developed by the authors, increase with an increase in the depth of penetration. This increase in moment is contrary to experience with medium to dense sands. In Mr. Rowe's procedure, the free-earth-support method is followed by a reduction of bending moments to account for the effect of fixation at the toe on the change of bending moments. This reduction is shown by the change of curve A to the bending-moment curves illustrated by curves B and C of Fig. 6(*a*). The writer's method (Fig. 6(*b*) and Eq. 40) can also be adapted, by varying the coefficient f''' so that the maximum bending moments shown by curve B will reflect conditions of the type corresponding to curve C in Fig. 6(*a*). This latter procedure is more flexible and can more readily reflect many imponderables which lead to the inevitable scattering of results which occurs in the field. This scattering of results was observed during the tests performed by the writer (Fig. 7).

For flexible bulkheads, appreciable reductions of the bending moments proposed by the authors are indicated. Under the heading, "Method of Developing Data for Charts: Design Example," a sample design is presented in which H_P/H' is equal to 0.53. This value exceeds that needed for full fixation in the case of medium to dense sand (H_P/H' equal to 0.43). Computations based on Fig. 6(*b*) result in a maximum positive bending moment of + 34,400 ft lb in the sheet piling. This moment is 43% of the bending moment of 79,860 ft lb computed by the authors' free-earth-support method. Mr. Rowe's data[23] shows that steel piling stressed to 18,000 lb per sq in., as well as reinforced concrete piling stressed to f_c = 1,250 lb per sq in. (permissible in concrete with a 28-day strength of f'_c = 2,760 lb per sq in.), will also be subjected to approximately 45% of the bending-moment values obtained by use of the free-earth-support method. This proves that the writer's design procedure (Fig. 6(*b*)) automatically gives the strength required by the corresponding flexibility of steel sheet piling and of piling made of medium quality concrete. For timber piling and for higher quality concrete, designs according to Fig. 6(*b*) will give conservative values; such designs will be on the unsafe side only for low-grade concrete (f_c = 750 lb per sq in., f'_c = 1,670 lb per sq in.).[23] Such poor concrete should never be used in waterfront structures.

WALTER C. BOYER,[24] A. M. ASCE, AND HENRY M. LUMMIS, III,[25] J. M. ASCE.—Mr. Tschebotarioff has contributed a stimulating discussion, and has pointedly indicated the area of usefulness of the design charts. His interpretation, however, is subject to careful scrutiny and is a matter of opinion.

The function of the paper was to present a useful tool to the practicing engineer. In no sense can it be construed to be a paper reporting the research

[23] Discussion by P. W. Rowe of "The Design of Flexible Bulkheads," by James R. Ayers and R. C. Stokes, *Transactions*, ASCE, Vol. 119, 1954, p. 389, Fig. 13(*b*).

[24] Asst. Prof. of Civ. Eng., The Johns Hopkins Univ., Baltimore, Md.

[25] Engr., Sverdrup & Parcel, Cons. Engrs., St. Louis, Mo.

on flexible-pile bulkheads. The writers were faced with the problem of adopting generalized criteria which could be considered applicable to a complete range of pile flexibilities and soil conditions. Mr. Tschebotarioff has termed the resultant work "conservative." Since the charts were intended primarily for preliminary design, this is felt to be necessary and desirable. No claim has been made to originality in the fundamental assumptions, but these have been set forth clearly to permit appraisal of the resultant charts. Accordingly, it is difficult to conceive that a designer would utilize the charts without realizing their inherent limitations.

Mr. Tschebotarioff has questioned the interpretation placed on his writings concerning the increase of Rankine's passive coefficient by a factor of 2, as recommended by Mr. Blum. In further writings, however, he has stated:[26]

> "It should be noted in this connection that the doubling of the K_p value, as compared with the value obtained from Equation (10–7), was undertaken by Blum not because he considered the beneficial effect of wall friction (Art. 1–5), but because of the results of previous tests by Franzius (Ref. 136, 1927) at Hannover. During these tests, Franzius obtained very high values of passive resistance and recommended doubling the values of passive resistance obtained by the use of the heretofore customary equation (10–14a). The direction of the wall friction (Art. 10–5) was not given any consideration by this recommendation, which should therefore not be used indiscriminately. The test box used by Franzius was 3.3 feet wide and 4.9 feet high. Therefore, side-wall friction may have had a very great influence on the increase of the passive resistance of the soil in the box when the front wall was pushed in. It is questionable whether his test data can be applied to a normally long wall under field conditions."

Other writers[27] have indicated similar concern with this procedure; accordingly, the use of Rankine's passive coefficient, K_p, without increase was adopted in this paper. Mr. Tschebotarioff's findings[11,13] were not available at the time this paper was prepared. However, one can question the advisability of interpreting ultimate toe-pressure development as an increased value of Rankine's passive coefficient. Presumably the toe pressure is a function of pile flexibility, wall friction, toe shear, and the vertical component of active soil as proposed by Mr. Rowe.[28] One should not conclude that doubling the value of Rankine's passive coefficient will result in substantial reductions in the design characteristics of sheet-pile walls, as can be seen from Table 3. It can be noted from Table 3 that doubling the value of Rankine's passive coefficient primarily influences the depth of penetration in the free-earth-support method of design but does not similarly influence the anchor tension or maximum bending moment. Using a value of K_p equal to unity results

[26] "Soil Mechanics, Foundations, and Earth Structures," by Gregory P. Tschebotarioff, McGraw-Hill Book Co., Inc., New York, N. Y., 1951, p. 499.

[27] "Design of Steel Sheet-Piling Bulkheads," by Raymond P. Pennoyer, *Civil Engineering*, Vol. 3, 1933, p. 615.

[28] "Anchored Sheet-Pile Walls," by P. W. Rowe, *Proceedings*, Inst. of C. E., London, England, Vol. 1, Pt. 1, 1952, p. 60.

TABLE 3.—THE EFFECT OF VARYING K_p

Design characteristic	Design charts	Analytical solution	
Coefficient of Passive Resistance	K_p	K_p	$2\ K_p$
Maximum bending moment, in foot-pounds per foot of wall	79,860	79,589	72,060
Anchor tension, in pounds per foot of wall	11,616	11,625	11,168
Depth of penetration, in feet	13.86	14.02	11.63

in a depth of penetration that is considered adequate without an additional increase as normally recommended in design procedures.

Mr. Tschebotarioff has placed a limitation on the value of the charts, relegating their usefulness to the practical design of very rigid walls in loose sands. This conclusion is based on a chart[21] similar to Fig. 8. In Fig. 8, M_D is the design moment reduced as a result of Mr. Rowe's tests, and M represents the bending moment as determined from the charts. Reference to

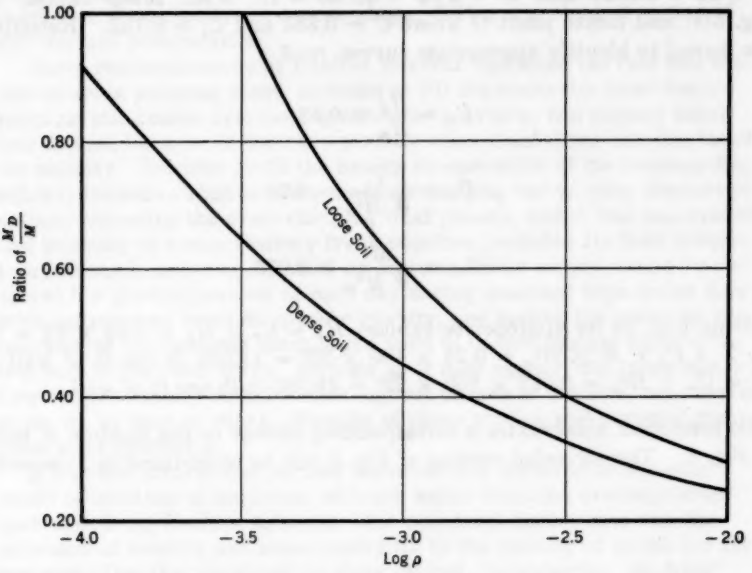

FIG. 8.—THE EFFECT OF FLEXIBILITY ON THE BENDING-MOMENT RATIO FOR VARIOUS SOILS

Fig. 8 indicates that for very rigid walls ($\log \rho > 3.5$) and loose soil, no moment reduction is permissible. Fig. 8 also forms the basis for Mr. Tschebotarioff's statement that, for the design example, the reduction chart offered by Mr. Rowe causes a design moment which is 45% of the value, 79,860 ft lb per ft. This conclusion is concurred in, and it is strongly recommended that the design charts be used in conjunction with Mr. Rowe's reduction chart. Under this condition, the charts have a wide area of usefulness—ranging from relatively rigid concrete piling to flexible timber piling.

Corrections for Transactions.—
The expression for P_s in Eq. 4 should read

$$P_s = \frac{K^2_2 (H_s W + H W + H_w W')^2}{2 W' (K_3 - K_2)}$$

Eq. 25 should be changed to

$$C_m = C^2 C_s \frac{K_1}{2} + C_3 \frac{K_1}{6} - C^2_2 \frac{2}{3} F - C^2_2 \left[\frac{K_2}{2} (C_s + C) \right]$$

Under the heading "Method of Developing Data for Charts: Design Example" the following text should be substituted:

To demonstrate the use of a design chart such as Fig. 5, assume $H_s = 4$ ft, $H = 8$ ft, $H_w = 22$ ft, $W = 100$ lb per cu ft, $\phi = 30°$, and $\phi' = 30$. With these data, it is possible to compute $C = H/H_w = 8/22 = 0.364$; $C_s = H_s/H_w = 4/22 = 0.182$; and $N = \phi'/\phi = 30/30 = 1$. With these values, enter Fig. 5(*e*) and locate point O where $C = 0.364$ and $C_s = 0.182$. Referring to the legend to identify appropriate curves, read

$$C_p = \frac{H_p}{H_w} = 0.63 \quad \text{.....(39}a\text{)}$$

$$C_t = \frac{T}{W H^2_w} = 0.24 \quad \text{.....(39}b\text{)}$$

$$C_m = \frac{M}{W H^3_w} = 0.075 \quad \text{.....(39}c\text{)}$$

Solving Eqs. 39 for appropriate values—$H_p = C_p \times H_w = 0.63 \times 22 = 13.86$ ft; $T = C_t \times W \times H^2_w = 0.24 \times 100 \times \overline{22}^2 = 11{,}616$ lb per ft of wall; and $M = C_m \times H^3_w = 0.075 \times 100 \times \overline{22}^3 = 79{,}860$ ft-lb per ft of wall.

This correction necessitates a corresponding change in the location of point O in Fig. 5. The corrected version of Fig. 5 will be reproduced in *Transactions*.

DISCUSSION OF SALT WATER BARRIERS IN THE SAN FRANCISCO BAY PROCEEDINGS-SEPARATE NO. 259

CLARENCE S. JARVIS,[4] M. ASCE.—Early reports on salt water barriers have been cited by Mr. Nishkian, including the interest that this subject held for C. E. Grunsky, M. ASCE. Parallel experience at Benicia Arsenal, Calif., should provide some worthwhile constructive comparisons useful in discussion. In 1919 the writer was assigned to the problem of making special studies and reports on the water supply situation and to recommend means of relieving the acute shortage. Conveyance by barge from San Rafael had become an established practice to supply both culinary and garden needs, as well as the requirements for the extensive ordnance shops, during a prolonged period of sub-normal precipitation.

Early reconnaissance at Benicia Arsenal disclosed the fact that the commodious pumping plant, intended to fill the concrete-lined reservoirs on hill crests overlooking officers' quarters, had largely fallen into disuse, because of the rare periods when flood flows had displaced the salinity. However, with the hearty co-operation of the commanding officer, intensive studies were made concerning the varying degrees of salinity attending the ever-changing tidal phases, and it was discovered that pumping of comparatively fresh supplies, suitable for both irrigation and stock-watering, as well as ordnance shop supply, could be resumed for limited periods of each day during seasonal high-water flow. Both hydrometer tests of specific gravity, and tasting the water by the operator at the pumping plant, were used to insure against salinity intrusions to the reservoirs. Strange as it may appear, the fresh-water flow did not exactly coincide with highest phases of the tide, but seemed to lag by an hour or more. Results of those studies and pumping operations were gratifying.

It was but natural that further attention was directed to the utter waste of millions of acre-feet of fresh water from the drainage area upstream from Benicia Arsenal. One climactic occurrence was the intrusion of salinity and associated filth to the vicinity of intake for the pumping plant that supplied the state capital, Sacramento. No doubt there were earlier births of the salt-water barrier concept; but for the writer, it seemed like a new and startling idea at that time. He devoted week-ends and holidays, as well as extra hours on ordinary days of duty, to working out the details of a technical paper on the subject[5]; and

4. Cons. Engr. (Retired), Salt Lake City, Utah.
5. "Control of Flood and Tidal Flow in the Sacramento and San Joaquin Rivers, California," by C. S. Jarvis, Transactions, Vol. 84, 1921, p. 455.

the completed manuscript, with maps and other illustrations, was submitted to Mr. Grunsky, the most outstanding consultant in the region. His kindly reception and fatherly interest overwhelmed the writer from the beginning of the ensuing association.

After painstaking reading of the manuscript, Mr. Grunsky commented as follows, according to the writer's memory.

> "You have something here. I once suggested the idea, myself; but I did not press it whole-heartedly and to the limit, because of the enormous volumes of river-flow to be accommodated during seasons of high flow, and the dire results that might accrue from overtaxing those miles of protective levees in the island district, near the main river junctions. Of course, we have gone a long way in the forty years since I first had that concept, in providing effective spillways of great capacity, and insuring automatic operation. I advise you to submit your paper to the A.S.C.E. Their well-grounded conservatism may prevent acceptance and publication at this time; but your plans and ideas would be on file against the time whey they would be acceptable. I am glad, individually, to indorse the ideas."

After publication of the paper in Proceedings, several well-qualified consultants made valuable contributions, some of them even bringing forth records of deep borings for foundations at designated sites. Further teamwork was afforded by authorized calls for studies regarding the teredo menace to wharves and shipping interests, as a result of continued and widespread depredations resulting from the intrusions of salinity farther inland, as diversions for irrigation and sub-normal precipitation continued as teammates in the upper valleys. At the October meeting of the Society in San Francisco in 1922, the writer's report received the generous acknowledgments of Walker Young representing the U. S. Bureau of Reclamation; and in the midst of his studies underlying the report mentioned in Mr. Nishkian's paper, Mr. Young accorded a gracious tribute to the earlier pioneers in this field of exploration and planning. The notable accomplishments, to date, in line with Mr. Young's report and recommendations, should engender confidence in other elements of the comprehensive plans and recommendations of the master plan which bears his name.

Students of salt water barriers should be reminded of a notable meeting of the Sacramento Valley Water User's Assn. about midyear of 1923. Litigation between the Upper and Lower River interests had already approached costs of $100,000 for each side in the controversy, related to increasing salinity as influenced by ever-increasing diversions for irrigation. The main elements of the proposed "salt water barrier" were briefly presented by the writer, by previous arrangements with those in charge; and at the psychological moment when it would be most effective, the State Engineer's Office representatives announced that the time has come to stop the wasteful litigation, and to divert the funds instead to U. S. Bureau of Reclamation investigations and planning for the necessary comprehensive projects. Funds were made available from both the litigants and the State Engineer, and they walked out of that meeting with the litigation ended, in favor of the

magnificent projects that are now under way, accomplished, or in prospect. Unquestionably, the salt water barriers must be included at the most feasible and effective locations, all things considered.

Mr. Nishkian's paper is both timely and vital, in meeting the issues so courageously and squarely, and claiming the attention of all who may be interested in the steady growth and development of a great commonwealth. The water resources annually wasted through the Golden Gate have potentialities far exceeding the values for which men stampeded more than a century ago. Transformation of major arms of the Bay into fresh water lakes should bring benefits far exceeding the costs involved, and should delay or eliminate the need for mammoth diversions and importations of water from distant watersheds. Earnest consideration is in order, along with recognition of the need for action.

DISCUSSION OF SOME ECONOMIC ASPECTS OF WATERWAYS PROJECTS PROCEEDINGS-SEPARATE NO. 318

DUANE ORR.[1] — Mr. Faison's paper on the Economic Aspects of Waterway Projects brings out many of the controversial points which exist between waterway enthusiasts and those opposed to Federal expenditures on such projects. His report concerns mostly inland waterway projects because these projects are the ones universally condemned by the interests that oppose waterway improvements.

The question is raised whether economists are more qualified than engineers to evaluate and determine the feasibility of a project. Very few, if any, engineers will concede that a pure economist is better qualified than an engineer of broad experience to evaluate the feasibility of a project. In most instances economists become so highly theoretical as to lose all sight of the practical side of the problem. Likewise, no one questions that it takes a person with special training and with practical engineering experience in waterways and transportation to properly evaluate a waterways project. The fact that the Corps of Engineers have been assigned the responsibility of evaluating, constructing and maintaining the Nation's waterways is not a temporary phenomenon to be deplored, but is the result of the thinking of the citizens who have brought about such a national policy.

The overall results of the waterway improvement program in the last few years have definitely shown that the expenditure of Federal funds was fully justified, although in some isolated instances a particular project may not have fulfilled all expectations. The fact that one project may prove uneconomical does not warrant a condemnation of all waterway projects. In most cases with which the writer is familiar changing conditions between the time the report was prepared and the time the project was completed have accounted for the actual tonnage falling below the original estimate. By the same token, on other projects, changing conditions after the project was authorized have caused the tonnage to far exceed the original estimate. In either case the estimates were wrong, yet the only criticism levelled at the engineers preparing the reports was in those instances when the actual tonnage fell below the original estimate, not when the tonnage exceeded the extimate. The writer acknowledges that in some instances borderline cases should have received further study and verification before submitting a report on their feasibility, yet in many cases it is extremely difficult, if not impossible, to develop all the information about a project within the time alloted for preparing the report.

The Gulf Intracoastal Waterway, extending from New Orleans, Louisiana, to Brownsville, Texas, is a typical example of an internal

1. Dist. Engr., Port of Corpus Christi, Nueces County Navigation Distr., C. C., Tex.

waterway that has exceeded the Engineers' estimate of potential tonnage by six fold, and the tonnage is still increasing, yet few of the feeder canals projected for the waterway have been completed. Completion of the feeder canals will further increase the tonnage on the main artery, although dredging of the feeder canals may in some instances divert the origin of tonnage from one feeder to the other.

However, the net results will be increased use of the waterway because new tonnage not now available to the waterway will originate from points on the new canals.

The criticism that the cost of construction of a project exceeds the Engineers' estimate and that the tonnage using the waterway during the early periods after the project is completed fails to equal the estimates shown in the report authorizing the project is hardly justified in many cases. In some instances this criticism may be justified, but in most cases a study of the background of the project will reveal that it was authorized several years before the first appropriation was made, and several more years elapsed before construction was completed. Because of this delay, construction costs may have changed greatly from those used in the original estimate, and likewise the tonnage may vary greatly from the original estimates because of changes which occurred between the time of the original report and the time the waterway is opened for traffic. It appears that a plan should be developed whereby the lag between authorization and construction of a project would be limited to a reasonable period of time, or if this is not feasible, a plan whereby the merits of a project are reviewed prior to the expenditure of the first construction funds to determine if conditions have changed since the original authorization that would affect the feasibility of the project.

In this connection it is the writer's opinion that the overall development of a waterway or basin project should be authorized at one time rather than authorizing the project on a "piece meal" basis, as was formerly the policy. A long range over all plan for development of the potential waterways is certainly a more desirable and a more sensible plan of approach to the problem, although many years may elapse before some sections of a project can be completed to project dimensions. A master plan for the development of all potential waterways with priority assigned to each waterway and to each section of a project based on existing conditions would certainly be a step forward in solving the dilemma which exists now in developing the nation's waterways. In this connection an over all plan for the complete development of a waterway would permit a more proper evaluation of the potential tonnage that would use the waterway, and under this plan potential tonnage on feeder canals and the main waterway could be properly credited to the respective sections.

There are those who continually insist that use charges be placed on uses of the nation's waterways. As pointed out by Mr. Faison, this involves a very complex policy of many years standing in this country and is one that can be debated pro and con without an agreement ever being reached.

The national defense aspect of waterways is certainly one that cannot be overlooked or taken lightly for the use made of the inland waterways during the last war proved conclusively the value of these waterways,

and the results justified all the money which the Federal Government has spent in improving and maintaining the nation's inland waterways. In the event of another war no doubt the rail and highway transportation facilities of this country will be far more taxed than they were during the last war, and based on past experience, the use of ships in coastwise service would not be feasible even if the ships were available. A well developed national waterway system can in times of emergency carry large tonnages with little equipment and is subject to few of the hazards experienced by ocean shipping. Full utilization of the waterways will permit the railroads and highways to carry finished products and war materials which are so urgently needed in time of war.

In conclusion the one and only test of a public works project is the extent of public benefit. Waterway projects fall within this category and if after careful engineering analysis benefits or savings exceed all legitimate costs chargeable to the project, then the project must be considered feasible and justified from the standpoint of the public.

L. P. COOKINGHAM, Esquire.[2] — The interest of Kansas City in the development of Inland Waterway Projects is twofold — first, the development of bulk cargo shipping on the Missouri River; second, effective control of the river flow in times of flood and drought alike. The future development and the vital position of Greater Kansas City in the dynamic economy of these United States rests heavily upon the public's understanding of the importance of a forward looking national water resource development policy. Mr. Faison has indeed performed a commendable public service by presenting a factual analysis of this widely misunderstood problem to the members of the American Society of Civil Engineers.

Greater Kansas City is located at the confluence of two rivers, the Missouri and the Kansas. The local flood protection works, now substantially complete, are designed to work in conjunction with upstream reservoirs, capable of retaining large volumes of water in time of flood and releasing the impounded water in periods of drought. Unfortunately the construction of these reservoirs has not progressed to completion and Kansas City is still subject to wide fluctuations in the river flows.

The Kansas City area is widely recognized as a large and important industrial, marketing, and transportation center. The facilities of the City also serve a wide trade territory extending in all directions. Approximately 26 square miles of Greater Kansas City lie in the area depending upon the local flood protection structures. It is estimated that from 85 to 90% of the industrial facilities representing a property value alone of approximately $936,000,000.00 are located in this area.

The Great Flood in Kansas City in 1951 resulted in an economic disaster without parallel in out nation's history. Estimates of damage range from one half billion dollars upward. Local protection works prevented flood damage of approximately 264 million dollars. Had substantially all the planned upstream reservoirs in the Kansas River Basin been in operation, virtually the entire tragic loss could have been prevented.

In 1952 the Missouri River rose to record heights in Kansas City, but local protection works operating in conjunction with upstream

2. City Manager, City of Kansas City, Missouri, since 1940.

reservoirs, now completed in the North, prevented a recurrence of the flood disaster. Savings resulting from the operation of local flood protection works in 1951 and 1952, constructed at an approximate cost of 49 million dollars, amount to approximately 8 times the construction cost.

The construction of upstream reservoirs to permit a regulated flow of the two great rivers at Kansas City is not only essential to flood protection and navigation but also to insure an adequate supply of water in times of drought, to meet the needs of the City's growing population. Water supply and sewage disposal alike are dependent upon the maintenance of a certain adequate flow in the rivers. The partially completed system of reservoirs on the upper Missouri River provided the storage from whence came approximately 75% of the river flow below Sioux City during the severe drought conditions of last summer and fall. The DuPont Company, in a current employee magazine, has this to say about the use of water in industry, "When DuPont engineers set out to scout new plant sites, a prime concern is a source of water. The reason is basic: water is DuPont's most valuable raw material."[3] Reasonable assurance of flood protection, and water supply as well, are necessary if Kansas City is to compete favorably for the location of new and expanding industry.

Kansas City had its humble beginning as an important landing on the Missouri River, then a principal channel of trade in the 1880's. The growth of other methods of transportation dimmed the importance of river shipping for a time, but today our expanding industries urgently require the greatest, most complete, integrated system of all modes of transport. Evidence of renewed interest in transportation by water is reflected by the fact that two competing barge lines have recently inaugurated service. No less impressive is the fact that while the only regularly scheduled service through Kansas City in the past was the government subsidized Federal Barge Line, tonnage handled at the City Municipal Wharf increased from 27,143 tons in 1949 to 44,957 in 1953, or 65.6%.[4] Vessel traffic in tons, Kansas City to Sioux City, increased from 275,354 in 1946 to 1,646,048 in 1952; and from Kansas City to the mouth, traffic increased from 748,556 to 1,198,656 in the same period, exclusive of rafted shipments.[5]

The system of inland waterways may well be considered among our nation's greatest assets, both in time of peace and war. Certainly it is easily understood that Kansas City, a dynamic agricultural and industrial center, strategically located for the manufacture of materials for the nation's defense, as well as serving as the gateway to the great Middle West, must again become an important river port, a well integrated part of the inland waterway system. Years ago, General T. Q. Ashburn, of the Inland Waterways Corp., speaking to the American Society of

3. "Dams, Drouth and Industry," Editorial in the Topeka State Journal, September 10, 1953.
4. Office of the Director of Finance, City of Kansas City, Missouri.
5. Chamber of Commerce, Kansas City, Missouri.

Civil Engineers at Milwaukee, said, "If our navigable highways are developed as they should be, it will be only a matter of a few years till such cities as the Twin Cities, Kansas City, Omaha, and many others will be actually if not geographically seaports."[6] The expansion and improvement of air and rail transportation in Kansas City has resulted in an indisputable economic gain to the area. Transportation by water represents a relatively undeveloped potential which will contribute importantly to the increasing prosperity of the metropolitan area and trade territory alike. Indeed, the Missouri River as an inland waterway may carry Kansas City to presently unforseeable economic and industrial development.

Colonel L. J. Lincoln, then District Engineer of the Kansas City District, Corps of Engineers, addressing a civic group in Kansas City, in June 1953, remarked, "Greater Kansas City would be short-sighted if it did not include in its plans additional wharf sites and facilities to cope with the increased river traffic that is bound to come."[7] Mr. William G. Oliphant, President of the now privately-owned (St. Louis Shipbuilding Company) Federal Barge Lines, and Captain Dave Parker, President of the Sioux-New Orleans Line, which recently inaugurated service on the Missouri River, speaking before the Kansas City Council of the Mississippi Valley Association on January 29, 1954, informed the group that in view of present commitments, it was anticipated that the tonnage of freight handled in 1954 would be double the 1953 volume. Officials of Kansas City were urged to provide adequate facilities to accommodate the increased river traffic. The City of Kansas City, Missouri, has included in the immediate work program the expansion and improvement of the Municipal Wharf. Long range programming presently envisions the expenditure of substantial sums for the construction of an additional Municipal Freight Terminal and attendant facilities. Adequate facilities will be provided to keep pace with this important and expanding complement to our transportation system.

Estimates of potential traffic load on the Missouri River range from 4 million to 5 million tons annually, according to recent surveys.[8] Previous estimates of the economic potential of the Kansas City area have proven far too conservative. It appears more than possible that the predictions of this one segment of the area's economy may likewise be underestimated. If so, the situation will be far from unique in view of the numerous similar examples cited by Mr. Faison.

The writer has recently returned from an extensive official tour of Western Germany. Personal observation of the amazing economic recovery attained in a relatively short period of time results in the firm conclusion that the extensive use of the extremely well developed inland waterway transportation system is responsible, in large part, for this phenomenal progress.

---

6. Louisiana Purchase V Part II, "The Steamboat and the Great Plains Empire," Waterways, December 1953, p. 46.
7. "A New Frontier for Kansas City," Address of Colonel L. J. Lincoln, Kansas City District Engineer, before Kansas City Breakfast Club, Kansas City, Missouri, 2 June 1953.
8. "The Missouri River Basin Development Program," Missouri Basin Inter-Agency Committee, June 1952, p. 23.

MARVIN B. MARSH, Esquire.[9] — In presenting the economic aspects of inland waterway projects, Mr. Faison has made a great contribution toward the systematic and economical development of the transportation resources of the United States. It will serve to clarify the important place inland waterway facilities occupy in meeting the overall transportation needs of the country.

Unfortunately, for many years there have appeared in widely-circulated publications of various types, a procession of non-factual statements and allegations minimizing the function of inland waterway projects in our nation's transportation system, and misleading the public as to the true ratio of costs versus benefits of such projects. In the absence of complete information, the validity of these statements has been accepted by the general public to the detriment of waterway development. The appearance of Mr. Faison's paper in a publication of the American Society of Civil Engineers is of great importance in establishing by professional discussion the true values of the many facets of water transportation.

Mr. Faison's examples did not include specific reference to Missouri River navigation, except as a part of the national inland waterway system; but navigation on this river could well have been selected as an excellent example of a sound economic and much needed waterway development. This conclusion is based on the writer's experience in recent years as a member of the River Navigation Committee of the Kansas City Chamber of Commerce and as Chairman of the Kansas City Council of the Mississippi Valley Association, whereby he had the responsibility of reviewing and studying all available factual data pertaining to navigation on inland waterways. Further, the writer is engaged in a business of such a nature and location that the dependable and economic transportation of approximately 50,000 tons of steel per year is the most vital factor in its operation. At least one quarter of the total cost of steel delivered in the Kansas City trade area is composed of freight costs alone, unless water transportation is used, but with barge shipment, the freight charges become a relatively unimportant item in the final cost of the finished product. For example, all steel products coming into Kansas City in 500-ton minimum barge-loads from the two major producing points (Chicago and Pittsburgh), are subject to the following comparative freight charges:

	From Chicago	From Pittsburgh
Rail Charges to Kansas City	$15.40 per ton	$20.85 per ton
Barge Cost to Kansas City[10]	6.52 per ton	8.43 per ton
Savings via Barge	$ 8.88 per ton	$12.42 per ton

The time of the cargo in transit by barge is only a few days longer than by rail; the cargo in a barge is never damaged by rough handling

9. President, Marsh Steel Corporation, Kansas City, Missouri.
10. This includes an unloading charge of $1.00 per ton at Kansas City wharf, plus $.65 per ton charge for drayage to any plant in Greater Kansas City.

through hump yards or by switching; it is never damaged by moisture due to condensation in transit, as is so often the case in rail transit where a car moves through chilly nights and warm days, because the cargo in a barge is kept at constant temperature always being below the water line. Furthermore, barge equipment, that brings steel and other commodities into the Kansas City area for consumption, is then available to take out grain and other commodities produced in this region to markets that would otherwise be too costly to reach and to many markets already being reached by other means of transportation—at a tremendous savings to both producer and consumer.

Mr. Faison's findings that the actual development of traffic volume generally exceeds estimates made to substantiate planning recommendations, are also borne out by experience on the Missouri River. The important use of this river during World War II is so well known that elaboration is not necessary. In 1953, in spite of the facts that (a) only a small portion of the potential users of barge transportation were unaware of its benefits, (b) loading of all barge equipment had to be limited to about sixty per cent of capacity in order to navigate a six foot channel since the standard nine foot channel is not yet completed, (c) the wharf facilities were very limited and somewhat awkward for large tonnages, and (d) obsolete inefficient equipment was used for most of the tonnage hauled during the entire season (a few modern towboats and barges made a trip or two at the end of the season) — and still in 1953, commercial traffic on the Missouri River exceeded fifty million ton miles. River conditions are constantly improving (a nine foot channel is now available for more than ninety per cent of the distance between Kansas City and the mouth), additional and improved wharf facilities are being planned, new privately owned barge line operators are placing in service modern equipment especially designed for Missouri River conditions, and there is an ever growing appreciation by the public of this great natural resource in the Missouri Valley. There is no question in the writer's mind that the trend shown in the graph on page forty-five of Mr. Faison's paper for the Mississippi River System (1927 to 1950) will soon be duplicated on the Missouri River.

The author, on page twenty-three, states the chief opponents of the Federal waterway improvements are the railroads. This is true on the Missouri River where a few of the railroads serving Kansas City are constantly fighting navigation on the Missouri River with non-factual and unprovable statements. These same railroads stand to gain tremendously in the future by the benefits of new and greater industrial enterprises and enlarged agricultural activity, all created by Missouri River navigation. They lose sight of the fact that federal funds spent for stabilization of the Missouri River, which keeps their roadbeds and bridges from being washed away by a meandering, uncontrolled river, is the main expenditure required for the development and maintenance of a navigable channel. A good channel for navigation purposes is a natural by-product of river stabilization, especially on the Missouri River where locks are not necessary.

The quantity and quality of the services which can be provided by river barge have been established beyond any question for hundreds of

important commodities. All that remains is public appreciation of the advantages of competitive waterway transportation.

Businessmen, as well as engineers, should study Mr. Faison's paper carefully, so that the admittedly difficult problems concerning development of transportation can reflect proper evaluation of all resources in this field. His conclusions are especially pertinent for the part of the United States known as the Heart of America, for in this area the development of industrial and agricultural potentials can be advanced way beyond the most vivid imagination of the majority of our citizens by the early realization of river transportation.

OWEN G. STANLEY,[11] M. ASCE. — Mr. Faison's excellent article constitutes a long delayed answer to much unjust, untrue, and unwarranted criticism of navigation projects and the work of the Corps of Engineers in general. It is too bad that this adverse criticism has been left unanswered for so long. My discussion will merely be an attempt to amplify some of the points made by the author and possibly to promote a better understanding of some parts of the article.

The statement in Mr. Faison's article that "each author, compiling and quoting the allegations of his predecessors, sometimes adding new ones of his own, without, apparently, any very diligent effort at verification" expresses a typical situation. Apparently the truth of an allegation is of no particular importance to these authors if it appears to support the point they wish to make. Further along in his article Mr. Faison points out several such instances appearing in "Muddy Waters." Probably the most flagrant instances of such tactics in "Muddy Waters" appears on pages 249 and 250 of that book. Near the bottom of page 249 is a tabulation purporting to give, for the Kings River project, the annual benefits assigned to flood control and irrigation in various reports by the Corps. The last column of this tabulation purports to quote the figures for the benefits of the Kings River project given by the Corps in the "Supplement to Comprehensive Report" (H. D. 367, 81st Cong., 1st Sess.). The annual flood control benefit is quoted as $2,126,000 and the annual irrigation benefit as $3,382,000. The values quoted in "Muddy Waters" as being in H. D. 367 differ materially from those given in previous reports of the Corps, and the author of that publication goes on to relate his version of the reasons for the change noted. His narrative on this subject is, to say the least, very uncomplimentary to the Corps of Engineers. He implies that the Corps of Engineers was shifting flood control benefits accruing in Tulare Lake from the Kings River project (then already under construction by the Corps) to the Kaweah, Tule and Kern River projects in order to justify those projects and obtain funds for their initiation as Corps of Engineers undertakings. Astonishing as it may seem, a perusal of H. D. 367 (see pages 26 and 44) shows that the figures quoted by the author of "Muddy Waters" are not those which appear in the report of the Corps. The annual benefit for irrigation given in H. D. 367 for the Kings River project is $2,656,000. The total annual flood control benefits accruing to the Kings River project are not separately given, being listed in that document as $312,000 along Kings River itself, and $4,311,000 in Tulare

11. Special Assistant to Div. Engr., Corps of Engrs. U.S. Dept. of the Army, San Francisco, Calif.

Lake, into which Kings River flows. The benefits in Tulare Lake, however, would be the combined effect of reservoirs on Kings, Kern, Tule and Kaweah Rivers. It therefore would seem quite evident that the figures quoted in "Muddy Waters" in this instance were given, regardless of the facts, merely to furnish foundation for the derogatory argument which followed.

The treatment by Mr. Faison of the objections raised in "Muddy Waters" to the counting of benefits incremental to those already accruing on traffic diverted from the Mississippi River emphasizes the need for a better and more widespread understanding of the sound economic principle underlying the Tombigbee waterway analysis. In effect, the same principle as that employed in the Tombigbee waterway analysis really is invoked whenever an old building with still some useful life in it is torn down and replaced by a larger and more modern structure. For construction of the new building to be a sound economical proposition, the income from it must be sufficiently higher than the income from the old building to justify all the final charges; i.e., the increment of income must be sufficient to meet all the costs involved in tearing down the old building and erecting the new structure, and to provide a profit. It really is just as simple as that and no amount of bibliographic reference can change the fact. And the author's statement under "Incremental Benefits" that "It would make no difference in principle if the proposed diversion took every ton of commerce from the Lower Mississippi River and consigned that improvement to abandonment" definitely is sound as illustrated by the reference above to the replacement of an old structure by a modern one. The new structure merely must provide benefits sufficiently higher than the benefits from the old structure to justify all the costs involved in making the change.

In computing the saving due to certain navigation projects being discussed by the author, the "normal fully remunerative rate" was used to obtain the rate of saving, but from the description of the method of analysis employed, it would appear that probably the rate of saving was applied to only the traffic which actually moved over the waterway projects. As far as the shippers in the affected areas are concerned, the rate of saving properly could also be applied to the quantity of traffic still being carried by the railroads at the depressed rates in order to obtain the total savings the navigation projects really effected. This is so because if it were not for the navigation projects the shippers concerned would still be paying the "normal fully remunerative rate" on all the traffic, whether or not it now moves by water or by railroad.

The author's analysis of the value of a proposed feeder to an existing system is perfectly sound, but possibly it could be expressed more simply by merely saying "value of a proposed feeder to an existing system of waterways is the total value of the whole system with that feeder included less the total value of the whole system without that feeder." The correctness of the proposition as expressed could hardly be denied by anyone.

The author's contention that, in effect, the real objective of depressed rail rates is to drive out competing water transportation, and then, after the competition is gone, to return to the previous high, or even higher,

rates, quite evidently is true. Such tactics undoubtedly are very disturbing to industry, and, in certain instances, might even cause industrial establishments to fail. Undoubtedly, the procedure recommended by the author — that the railroads return their rates to the "normal fully compensatory" level and leave the low-grade freight to seek the low cost water transportation — would be better alike for the railroads, the shippers and navigation interests.

In addition to the author's objection to "User Charges," the following might be added:

a. The cost of administration and collection relatively would be very great in proportion to the funds collected.

b. Obviously, if charge is made for the use of one public improvement of this sort, it should be made for all — and even the railroads do not advocate any charge on certain waterway developments.

c. Great difficulty would be experienced in making and collecting fair assessments. The first thought would be to put the charge on a ton-mileage basis. But obviously that would not be fair to a barge drawing 10-feet say, but using a waterway with a 30-foot depth. The cost of furnishing the requirements of the barge might be little because of the natural condition of the waterway, while the costs of the 30-foot project might be great. Naturally, under those circumstances in fairness the barge should not be required to pay the same per-ton rate as the deep draft vessel which necessitated building the 30-foot depth.

An instance where this situation would be present is the Sacramento Deep Water Channel in California when that project has been completed. Shallow draft boats and barges plying from and to Sacramento are expected to use the deep water channel at very material reductions in operating time over the natural river route because of shorter distance, straighter alignment and avoidance of river current. But, of course, the shallow draft boats and barges will make no use of any depth over about 12 feet. Any "User Charge" in fairness would not be the same for this light-draft traffic as for the deep-draft vessels, and any attempt to collect such a charge probably would tend to drive a large part of the light-draft traffic back to the natural river channel and thus deprive the project of benefits it should develop.

The sentence reading "They do not add hypothetical tolls to the water rates because Congress has flatly rejected tolls . . . ." might give the impression that the formulae used by the Corps of Engineers leaves out some element of the cost because Congress has refused to authorize tolls. Such is not the case. All costs are included in the accounting by the Corps of Engineers. If tolls were charged, and the estimates of traffic remained the same, the form of the accounting formulae would have to be modified, but the end result — the benefit-cost ratio — would be the same.

The statement that "There would not seem to be any logical obligation on the general taxpayers or shippers to forego the benefits of economical water transportation in order to maintain a wasteful and inefficient competitor in business" presents perfectly sound logic. In this day of good highways and large trucking facilities, it seems probable that some of the less efficient railroads could now be liquidated to advantage

without material loss to the general public. What traffic of the eliminated railroads that could not be picked up by waterways and the more efficiently operated railroads could be satisfactorily handled by truck.

H. W. SCHULL, Jr.[12] — Mr. Faison's illustrations of the essential accuracy and the conservative nature of Corps of Engineers' traffic forecasts, as exemplified in the table of his article on page 318-7, are well substantiated by experience in Florida. The channel referred to in the following discussion is the Intracoastal Waterway from Jacksonville to Miami, which provides a 370-mile inland sheltered route along the east coast of Florida. The waterway is part of the Atlantic Intracoastal Waterway System extending northward to Trenton, New Jersey, and southward to Key West, Florida.

The original Intracoastal Waterway from Jacksonville to Miami was constructed by a private corporation and operated as a toll channel. When completed to Miami in 1912, the waterway was nominally 5 feet deep and 50 feet wide. Freight traffic on the waterway reached an all-time high in 1926 during the Florida boom. At that time a parallel railroad, unable to carry the traffic offered, had imposed an embargo on building materials and many other commodities. In the years immediately following the lifting of the embargo, traffic on the waterway dropped to the more normal average of about 150,000 tons a year.

In 1926, the Corps of Engineers estimated that normal traffic on the waterway would increase to at least 373,000 tons annually following enlargement to 8-foot depth and 100-foot width. Enlargement to those dimensions was completed as a Federal toll-free project in 1935. Traffic increased rapidly thereafter as is illustrated by the following statistics for the five-year periods before and after the improvement was effected:

Period	Average annual traffic, tons
1931-35, inclusive	241,000
1936-40, inclusive	460,000

Thus, the improved waterway almost immediately exceeded the tonnage estimate used for its justification. The five-year average tonnage movements have consistently exceeded the original estimate since the improvement was completed. While tonnage did not appreciably increase during the war years of 1942-45, the more intensive use is reflected in greater haul distances, causing ton-mileage figures to show an increase of more than 250 percent above normal levels. Much of that increase resulted from the wartime necessity of barging certain critical commodities via the protected waterway rather than in ocean-going vessels. The toll exacted by enemy submarines in the near-shore ocean routes was quite apparent in wrecked hulks and cargoes scattered along the Florida coast. At one time three separate ship casualties were visible from the same point on the beach.

12. Colonel, Corps of Engrs., U.S. Dept. of the Army, District Engr., Jacksonville, Fla.

In 1942, the Corps of Engineers recommended further enlargement to 12-foot depth and 125-foot width. Principal basis for that recommendation was a traffic forecast of 707,000 tons annually following the enlargement. Substantially all of the northern half of the waterway has now been enlarged as recommended. When the enlargement is completed southward to Miami, it is confidently expected that developing traffic will spurt to proportions which will once again prove the Corps of Engineers' forecast to be conservatively accurate.

N. C. MAGNUSON,[13] A.M. ASCE. — The Constitution gives the Federal Government jurisdiction over navigation by the "Commerce Clause" which states that the Constitution shall have power:

> "To regulate commerce with foreign nations, and among the several States and with the Indian tribes."

Chapter 2, Volume 3, of the Report of the President's Water Resources Policy Commission entitled "Water Resources Law," issued by the United States Printing Office in 1950, reviews the development of water resource policy under the Commerce Clause. The following quotation is from pages 11 and 12 of that publication:

> "The exercise of federal commerce authority to protect navigation including the prevention of interference with and obstructions to navigation—even those created under prior state or federal sanction —was repeatedly sustained. Correspondingly, exercise of that power in the construction of navigable channels and the Panama Canal was upheld."

Opponents of the waterway improvement projects do not generally dispute the right of the Federal Government to engage in such improvement, but attempt to discredit it by a deluge of criticism. Mr. Faison's paper describes the growth of water-borne commerce to a volume far beyond that estimated when the projects were recommended. The tabulation on page 318-17 indicates a benefit-cost ratio of 3.79 to 1. Time and space do not permit a complete discussion of the savings per ton, but the Ohio River seems typical. The referenced tabulation shows that in 1948 annual charges were $10,235,000 and savings $41,827,000. The annual report of the Chief of Engineers, U. S. Army, for 1949 shows that 42,792,000 tons of commerce were handled in 1948; as shown in the tabulation on page 318-7 it had increased to 48,598,000 by 1950. Total charges for amortization, interest, and maintenance and operation averaged $0.24 per ton in 1948; the savings averaged $0.98. The net savings after deduction of costs were thus $0.74 per ton.

It is stated on page 318-16 of the paper that the analyses cover the most important projects in the waterway system. It is believed that the smaller projects will show equal savings. Excluding the Atlantic Intracoastal Waterway (Wilmington District) the Wilmington District has six projects which handled between 28,000 and 600,000 tons of commerce in 1952; the total commerce moving over those projects was about 1,200,000 tons. Transportation savings are estimated at

13. Chf., Planning and Reports Branch, Wilmington District, Corps of Engrs., U. S. Dept. of the Army, Wilmington, N. C.

$1.00 per ton, or more. The greatest cost per ton for interest, amortization, operation and maintenance was about $0.25 per ton on the Cape Fear River above Wilmington. Other projects in North Carolina are of primary interest to commercial fishermen but they also handle various items of commerce in substantial quantities.

Several times in Mr. Faison's paper the statement is made that opponents allege that waterways are subsidized. In this regard it is well to remember that the railroads were heavily subsidized during their period of development. The following is taken from the Texas Almanac for 1943-1944 (Page 282) published by the Dallas Morning News:

> "Railroad building in Texas was encouraged during its early stages by large grants of land from the public domain, grants to railroads totaling 32,153,878 acres. Partly as a consequence of these grants and partly due to the intense competition to pre-empt territory in a region with obviously great potentialities, railroad building became a turbulent procedure characterized by ruthless methods and much abuse of priviledge."

If charges for transportation are based on the costs of providing transportation services certain types of commerce will increase on our waterways. On the other hand, it is believed that when the cost of moving freight by water approaches the cost of moving freight by land it will be transported by land. With our rapidly expanding economy there is room for the optimum development of all types of transportation, with each type handling the commodities it is best adapted for. Those charged with the development of our natural resources would be remiss in their duty if they did not seek full economical development of our navigable waters.

BRAXTON B. CARR.[14] — The paper by Mr. Haywood R. Faison on SOME ECONOMIC ASPECTS OF WATERWAY PROJECTS presents an interesting and timely discussion of some important problems involved in waterways development which too long have been obscured. The very fact that critical attacks on some phases of waterways development are in themselves carefully designed to be more attention-getting than the issues involved has had a tendency to leave the public poorly informed on many of the problems discussed by Mr. Faison.

Continuing critical attack on waterways development over the years has succeeded in creating adverse static opinion which must be penetrated, not only in the interest of waterways transportation but in the interest of a sound national transportation system. Criticism which seeks constantly to pit the weight of opinion against one basic form of transportation not only obscures facts necessary to progress and growth but operates in the long run to the detriment of the best interests of the promulgators of the attack as well as the system attacked.

It seems to us that Mr. Faison has rendered a service not only to the waterways interests, but to railroad interests as well if they will consider his findings objectively. The need is not for less transportation, but for more transportation with all phases integrated to complement each other. Water-borne commerce has demonstrated its value.

---

14. Executive Vice-Pres., Warrior-Tombigbee Development Assn., Birmingham, Ala.

Critical attack and tactics aimed at the destruction of waterways transportation ill becomes any responsible interests who have a stake in the continued growth of this country.

There are related benefits in waterways development which have a bearing on any ultimate assessment of the value of many projects which Mr. Faison has not discussed: In the Warrior-Tombigbee Waterway project, which is our primary interest, a more useful and a more efficient navigation project is the objective. But in achieving full development for navigation, stabilization of water supply must be accomplished and as a natural by-product better available water supplies will be created, health guards will be established by better pollution controls and certain flood control features will be incorporated as a matter of course and at little or no additional expense. Many other projects having navigation as their primary purpose incorporate such features. Any ultimate assessment of their true worth to the basic economy must take into consideration these features as benefits. We fully realize that they are by-products of navigation in a project such as ours, but they are tremendously valuable and realistically accessible as benefits.

C. E. CHILDE.[15] — If members of the American Society of Civil Engineers believe that they have a responsibility to guide the public in the wise and economical expenditure of public money, they should be critically and vocally aroused by Mr. Faison's paper on Some Economic Aspects of Waterway Projects, which combines a defense and explanation of the methods of the Army Engineers, with a discussion of the growth of inland waterways and important questions of public policy raised by their development. Since engineers are particularly qualified to form and express intelligent opinions on the economy, efficiency, and practical worth of engineering works, their views, as informed citizens and taxpayers concerned with the country's welfare, should be of special value to members of Congress, public officials, and the general public. But in the clamor of controversy about our national policies and expenditures for control and use of our water resources, I find little comment of a general nature from engineering sources, and much misinformation and ignorance which the views of informed engineers could counteract.

Mr. Faison calls attention to charges of certain economists supporting contentions of the railroads that inland waterways are uneconomic; that subsidized inland water transportation is unfair competition; that reports of Army Engineers approving such waterway improvements habitually underestimate costs and overestimate benefits; and that if true economic costs and value were taken into consideration there would be no justification for construction or continuance of many or most inland waterways.

Statistics cited by Mr. Faison effectively refute the contention that the Army Engineers overestimate in the reports the tonnage and consequent savings resulting from inland waterway improvements which they

15. Transportation Consultant, Washington, D. C. (Formerly Member, Board of Investigation and Research — Transportation Act of 1940; Chairman, Committee on Water Transportation Policy, President's Water Resources Policy Commission.)

recommend. The contrary is shown to be true — the completed inland waterways are currently carrying much larger tonnages than the engineers estimated, and savings in transportation charges are correspondingly greater than they originally predicted. It is true that sharply rising prices since the Second World War have increased costs of waterway improvements and other public works above original estimates. But it is also generally true that benefits have correspondingly risen. The soundness of the Army Engineers' estimates has not been impaired by the changes in price levels. Generally speaking, projects which were justified under the earlier price levels are equally justified under the higher prices prevailing when the projects were actually constructed.

It seems rather strange that so many economists, and even some public officials and reports continue to brand inland waterway improvements as unjustifiable, quoting old and inaccurate figures without taking the trouble to investigate results actually achieved and trends plainly indicated for the future. Is this because the cry of "pork-barrel" is sufficient to prejudice some minds, and that interests opposed to waterway development, desiring the preservation of the status quo, are more effectively promoting their cause than are those favoring the waterways? Engineers in government service are understandably reluctant to engage in public controversy. It is a good thing, therefore, that a man of Mr. Faison's ability and eminence should speak out.

After disposing of the contentions that the Army Engineers construction costs and tonnage estimates are overoptimistic, Mr. Faison proceeds to a discussion of the arguments that inland water transport is not truly economical and competes unfairly against railroads. The point that the benefits of low inland water rates are illusory is met by the Army Engineers' calculations of annual costs, including maintenance, interest, and return on the government investment, which show that the annual savings in transportation charges far exceed the capital and maintenance costs. As to alleged unfair competition of water carriers with railroads, which railroad protagonists insist should be corrected by requiring water carriers to pay "user charges" for the right-of-way provided by public funds, Mr. Faison concedes that "where rail carriers pay all expenses, including roadway, out of earnings, and water carriers pay nothing for the navigation facilities they use, an inequitable situation results." He is convinced, however, that under existing conditions, the imposition of tolls on the users of inland waterways would be a remedy worse than the disease. Difficult problems would arise of fairly allocating tolls to traffic, and of discriminations resulting from exempting Great Lakes and ocean traffic, as proposed by the railroads. But the greatest objection, in Mr. Faison's judgment, to imposing river tolls under present policies of railroad ratemaking and regulation is that the railroads are now, and would continue to be, permitted to cut their rates in order to drive traffic off the waterways, sustaining themselves in such rate wars by maintaining higher rates on non-competitive traffic. If the water carriers, without any backlogs of high-rated traffic and with their costs increased by tolls beyond their ability to bear, were forced out of business, the tolls, instead of yielding a return to the government, would make the waterways idle and the investment useless.

Unquestionably it is the present policy of the railroads, as it has been from the beginning, to maintain depressed rates below the full cost of the service on traffic for which water carriers can compete, so as to keep the traffic moving by rail. This policy, which is approved by the Interstate Commerce Commission, is so deepseated that it could only be corrected by legislation which would forbid the charging by common carriers of below-cost rates to meet competition of other lower-cost carriers. Until such a change in rate policy is adopted, the establishment of tolls or user charges on the inland waterways would tend to be self-defeating, except as an aid to railroads in suppressing water transportation. Moreover, the assumption is unjustified that the competition of toll-free water transportation is really injurious to the railroads. Analyses of the traffic and earnings of railroads in the Mississippi Valley show that they have been enjoying greater prosperity than the railroads and areas which are not served by waterways. They have gained much more through increased rail movements of high-grade manufactured goods, supplied by industries located on the inland waterways in order to obtain the benefits of low-cost water transportation of raw and semi-manufactured materials, than they have lost by reason of the water transportation of these low-grade commodities. Low-cost inland waterway transportation is thus proved to be essentially complementary, rather than competitive to rail transportation. Mr. Faison is over-generous in conceding that toll-free waterways are inequitable to the railroads, when the railroads are better off where they exist than where they are absent. Another point that must be considered is that the railroads themselves are direct beneficiaries of the federal expenditures, on rivers in the Mississippi Valley and elsewhere, for flood protection, which in the aggregate exceed in amount the expenditures for navigation. As long as the railroads pay nothing for flood-control works preserving their rights-of-way, they cannot consistently demand that the barges moving on the same rivers paralleling the railroad rights-of-way pay tolls for the water rights-of-way they use. A policy of requiring direct beneficiaries of public facilities to pay "user charges" making them self-sustaining and self-liquidating, might conceivably be as successfully applied to river and harbor works as to highways. In the final analysis the public would pay the cost either way, whether by general taxation or by tolls. But Mr. Faison effectively warns against the application of discriminatory or burdensome tolls which would impair or destroy the public value of the facilities.

Proposals of the railroads and some economists that reports and recommendations of the Army Engineers should not be adopted until they are investigated and approved by some other agency, such as the Interstate Commerce Commission or the Department of Commerce, are obviously for purposes of delaying and preventing construction of the projects. It is hardly necessary to point out that the public interest would not be served by such tactics.

Analysis of facts presented by Mr. Faison may fairly lead to the conclusion that the fault of the Army Engineers is not that they have been over-optimistic and extravagant in the estimates and recommendations for waterway improvements, but rather that they have leaned over backward and by their over-conservatism have failed to justify and

support a program of expenditures for waterway improvement large enough for the country's needs. Examples of important projects long-delayed or yet to be undertaken include the Missouri River, the Tennessee-Tombigbee Waterway, and the Lake Erie-Ohio River Canal.

A point of perhaps greater significance than underestimates of tonnage is that the Army Engineers in measuring the economic merits of a project seldom, if ever, go further than to compute savings in transportation charges which would result from construction of the new project. The benefits derived from cheaper transportation go farther than this. They are measured by the greater growth and prosperity of the community as resulting from stimulation of industry and increased utilization of human and natural resources. Such benefits are difficult to measure fully in dollars, but they are nonetheless real and important. The Army Engineers, instead of being labeled as over-optimistic and reckless spenders of public money, might well be warned that an excess of caution may be a more serious fault than over-optimism.

The Army Engineers' recommendations are sometimes criticized on the ground that they deal in piecemeal fashion with water resource development, without due consideration of over-all national needs. There are indeed some conflicts of both public and private aims with respect to transportation and other water resource development, in which Army Engineers' activities may clash with other agencies. The separate agencies cannot justly be held responsible for this situation. The fault lies in the lack of coordinating legislation. It could not be cured by switching engineering-economic functions from the Army to the Department of the Interior or Commerce or the Interstate Commerce Commission, as variously proposed. The President's Water Resources Policy Commission's report of 1950 has proposed that a coordinating Commission be created. Certainly the nation's transportation system of railways, highways, waterways, pipelines, and airways must be considered as a whole if we are to achieve and maintain a transportation system of greatest fitness and adequacy for our commerce and national defense. Coordination of all types of transportation service with competition limited to striving for greater economy and excellence of service must be the goal. To this end a federal transportation authority should be created to study continuously national transportation needs, capacity, and performance and to make recommendations to the President and Congress as to the desirability of public and private expenditures, as well as service needs and best methods of supplying them, and legislative and organizational changes needed to bring into being a coordinated national transportation system of greatest economy and efficiency. Within the framework of such coordinating authority, the Corps of Engineers' able and disinterested services could be utilized in carrying forward a program of waterway improvements to the country's utmost advantage.

The closing comments in Mr. Faison's paper may appropriately be quoted here:

> ". . . overall planning for the future and adherence to an accepted plan will go a long way toward simplifying these vital problems. But in the end the projects are going to have to be approached

piecemeal, with the most thorough possible analysis of their relation to the overall task, by experienced engineers of proven knowledge and judgment in both fields."

Mr. Harold Ickes, when he was Secretary of the Interior, said: "I believe I am one of the most criticized men in public life. Most of the criticism is unfair; it always makes me furious, but it never fails to do me a lot of good." Maybe this applies to the Army Engineers. Let them be critized, but in all fairness, let due acknowledgment be made of their fine record of patriotic, competent service dedicated to the public interest.

FRANCIS J. WILSON,[16] M. ASCE and N. R. GRAHAM.[17] — The author has performed a public service in explaining the procedures used for economic analyses of proposed inland waterways by the Federal Government and in refuting allegations made by opponents of waterways in their attempts to discredit these projects. As is usually the case with regard to any proposed public development, the opponents and critics are the vociferous and prolific element, and, unfortunately, not always respectful of cold, hard facts — with the result that the general public is left with a distorted picture of the issues involved. It requires efforts such as have been put forth by the author to establish a proper perspective.

No one denies that domestic freight transportation is one of our most important national activities. Its significance as a factor in unifying the states and in maintaining our high standard of living is incalculable. Approximate information is available on the extent and costs of the activity. The 1950 volume of inter-city traffic as reported by the Interstate Commerce Commission was over 1,000,000 million ton-miles or 24,000 ton-miles for each head of a household in the United States. Freight revenues during 1950 for transportation movements reported to the Interstate Commerce Commission amounted to about 11-3/4 billion dollars or about $275 per household head. This value should be considered only as a general indication of the costs of supporting the transportation system. Included in these figures are taxes to support Federal and local governments and excluded are costs of public aids and regulatory bodies and the costs of important transportation movements which are not reported to the Interstate Commerce Commission. It is evident that domestic freight transportation is exceedingly important and requires large expenditures for its upkeep. The importance of maintaining minimum total costs to the public cannot be over emphasized.

The trend of the volume of freight transportation has been upwards, the previous peak year of 1929 having been exceeded every year since 1940 and with the 1950 value about 165 percent of the 1929 value. However, the most interesting fact to be noted in a comparison of the annual transportation data for the past 20 years is the change in the relative portions of the total transportation load carried by the various

16. Cons. Engr. and Technical Advisor to Oklahoma Planning and Resources Board, Tulsa, Okla.
17. President, Tulsa Clearing House Association, Tulsa, Okla.

transportation agencies. Current indications are that this redistribution is still continuing. In 1929 the railroads carried about 74 percent of the total ton-mile traffic. By 1950 this had shrunk to about 59 percent of the total, despite the fact that their 1950 ton-mile traffic was substantially larger than in 1929. The decrease in the railroads' percentage of the total national traffic was occasioned by traffic increases in the pipelines, motor lines and inland waterways, with the larger increases gained by the first two agencies. The waterways traffic excluding the Great Lakes, while still relatively minor, increased from about 1-1/2 percent in 1929 to 5 percent in 1950.

An important factor in the increase of the inland waterway's share of the total traffic is the technological advances which have tended to reduce towing costa and increased the dependability of water-borne movements. Radar, channel depth indicators, more efficient propulsion units, streamlined and integrated tows are some of the recent innovations. These advances undoubtably are one of the reasons why the traffic has exceeded the originally predicted values.

The inter-agency shifting of the transportation load has touched off a determined bid by the railroads for a cessation and reversal of the current trend. Pipeline and Great Lakes traffic appear to be relatively immune to any likely action on the part of the railroads. However, they stoutly resist the expansion of the Great Lakes system in their opposition to the St. Lawrence Seaway. Highway and inland waterway transportation appear to be the two fields most susceptible to the competitive and political efforts of the railroads.

Most transportation specialists agree that vessel costs per ton-mile of lake and sea-borne traffic is the most economical of all transportation. Inland waterway vessel ton-mile costs are similar, the main difference in total costs being the difference in costs required to construct and maintain the inland channels as compared to harbor works. It follows that the total costs of inland water traffic decreases as the volume increases until the capacity of the waterway is reached. At some value generally far below the capacity of the waterway, the point is reached where the total costs of inland waterway traffic become more economical than overland transportation. The tabulation of savings earned by the 15 most important inland waterways in 1948 indicates the point of equal costs and benefits has been passed. The 1951 volume of all inland waterway ton-mile traffic excluding the Great Lakes, up about 44 percent over the 1948 volume, indicates the economy of the improvements are now even more favorable.

CHARLES L. HALL,[18] M. ASCE. — The writer is in complete sympathy with the reasons given by Mr. Faison, in his introduction, for writing this highly informative professional paper. Its preparation was certainly not an easy task. It might be well to point out that European engineers think that it is impossible, with the statistical evidence available to them, to determine the economic value of most waterways already in existence. In commenting on this writer's paper,

18. Retired; formerly Colonel, Corps of Engrs., U. S. Dept of the Army, Washington, D. C.

on the economic value of the improvement of the Ohio River, at the XVIIth International Congress of Navigation, the General Reporter (Jean Aubert of France) stated:

> "We consider that application of the method suggested by Colonel Hall would be difficult on most waterways, owing to the meagreness (insuffisance) of the statistical information usually available" (General Report on Third Communication, First Section, XVIIth International Navigation Congress)

It is believed that statistical information in Europe is plentiful. The difficulty lies in applying the information to a given concrete case so as to produce statistical evidence. If that is difficult after a project is completed and in operation, think of the difficulties in the case of a project existing only as a blueprint. If this question were to be treated as a contested argument, with no holds barred, it might be interesting to produce the advertisements for the original bond issues of all the railroad companies and compare them with the subsequent fate of the bonds.

The writer, as a member of the Navigation and Inland Waterway Transportation Task Committee of EJC, criticized on Page 318-15 of Mr. Faison's paper, does however, feel called on to come to the defense of that Committee. It is probably true that, as with all engineering committees with which this writer is familiar, the work of the task committee was farmed out; but a most intense effort was made to prepare co-ordinated findings satisfactory to all committee members. The quotation from the report given on Page 318-15, above cited, is not from Section XI, Summary of Conclusions and Recommendations (Pages 22 and 23, Report of Task Force on Navigation and Inland Water Transportation, Water Policy Panel of Engineers Joint Council, June 1950). The Task Committee recommended in that section "that study should be given to the practicability of levying charges upon the users, etc." This system of charging the users of federal services has now been suggested for a great variety of beneficiaries and is economically sound if it can be carried out. Incidentally the fourth paragraph of Section VII, Page 15, of the above cited report listed some of the difficulties in the matter of waterway tolls, and indicated the complexities of the study required. When reread after three years, the report seems eminently fair.

There is one matter referred to by the author which used to worry the writer when he was a member of the Board of Engineers for Rivers and Harbors. On page 318-19 it is said:

> "They have to determine only whether the proposed addition will pay for itself in added benefits, whether they occur on the project, itself, or are contributed by the project to the system as a whole."

There is no flaw in the logic here, but it may result in the justification of costs by counting benefits twice. The upper Mississippi improvement was partially justified on the basis of commerce expected to originate in western Iowa and eastern Nebraska. This was the area the commerce from which was later used to justify the upper Missouri

improvement. Criticism of such duplication may readily result from perfectly honest study at different times by different groups of engineers.

Mr. Faison apparently believes that the railroads will be permitted to depress competing rates forever, using the "added traffic" theory as justification. This difficulty can be avoided by requiring all carriers to fix their freight rates on a ton-mile basis. The writer was severely "spanked" for suggesting this remedy in a previous professional paper (The Logical System of Freight Rates by Charles L. Hall, Transactions ASCE, Vol. 115, page 33). At that time Mr. Faison was one of the few persons who came to his support. Mr. Faison refers (Page 318-33) to the fact that waterway transportation would disappear under a regime of tolls unless a rigid cost-of-service basis of competitive rail rates is imposed. Anyone who has struggled with any sort of rate fixing can tell all about the letigation before the Interstate Commerce Commission if high priced lawyers could argue about cost-of-service. It is an automatic device like the ton-mile charge which will settle this mass of potential disputes.

The writer again congratulates Mr. Faison on his paper.

JAMES W. DAVIS,[19] A.M. ASCE. — There has long been need for an analysis and public viewing of the typical criticisms directed at the civil works activities of the Corps of Engineers. Mr. Faison's paper contributes much toward this goal.

Attacks against the Corps of Engineers policy on waterway improvements are not unusual. The Corps policy has survived Congressional Committee investigations and many derogatory articles by well known authors in various publications. Because it has been able to survive the past allegations the Corps has been satisfied to ignore any new attacks.

The writer agrees that engineers responsible for the administration of river and harbor development have been too tolerant of invalid criticism. However, because such criticism is quite popular material for non-technical publications, the task of refuting the charges would be almost a full-time job.

Although Mr. Faison's article deals mainly with inland waterway development, the principles involved are equally pertinent to tidal waterways. The same procedures used to determine the economic feasibility of an inland waterway improvement by the Federal Government are applied to determine whether a coastal waterway merits improvement. Those who shout that Government subsidy of inland water carriers through Federal maintenance of the waterways creates unfair competition to land carriers are conspicuously absent from the ranks of those who oppose improvement of coastal harbors and their approaches. Perhaps it is not generally known that Federal improvement of any waterway — coastal or inland — requires three separate Acts of Congress. Is it not presumptuous therefore to maintain that the Corps of Engineers could conceivably provide a waterway improvement that was contrary to the desires of the general public?

19. Director, Port of Baltimore Comm., Baltimore, Md.

Federal improvement of waterways has been termed a subsidy of water carriers and a waste of taxpayers' money by opponents of such improvements. However, these opponents of the Corps of Engineers policies do not seem to object subsidies by non-Federal agencies. With the exception of the Port of Baltimore, every major seaport in the United States, Canada and South America contains extensive terminal facilities constructed by the States or municipalities in which the ports are located. The facilities are leased to users at rates which can never be hoped to approach a return that will cover retirement of the cost of the facilities and debt service during the normal lives of the structures. The economic theory behind this latter form of subsidy is identical to that motivating the practice of Federal improvement of waterways.

The author has shown by painstaking analysis and relevant statistics the soundness of public investment in waterway improvement and has masterfully pointed out that it is easier to be critical than correct.

HAYWOOD R. FAISON,[20] M. ASCE. — The generous comments of those who have concurred with this paper have fulfilled, at least in part, the author's hope that some of the commonly accepted fallacies about inland waterways have been brought to light. It was quite candidly admitted that the aspects treated in the paper were selected for their obviously favorable bearing. The author prefers to believe that limitations imposed by the rules of discussion, rather than lack of interest, prevented opponents of the federal waterways program from contributing adverse criticism. He readily conceded that there were unfavorable points not touched upon in the paper, and would have welcomed constructive criticism of those aspects.

Mr. Orr puts his finger on a sore spot in water resources development in deploring the unnecessary time lag between surveys, authorizations, and actual construction of projects. As he points out, the phenomenal growth of traffic of the Gulf Intracoastal canal and the Texas oil ports has caused the actual benefit-cost ratios greatly to exceed the original estimates. It seems clear that even with the most thorough investigation possible, had the trend been on the opposite slope of economic fluctuation, the reverse might have been true. He has wide support among engineers in his advocacy of fitting individual projects into multiple-purpose basin-wide development plans. The author, while inclined to go along with the principle, has been somewhat at a loss to fit such navigation projects as the Lake Erie-Ohio, the Tennessee-Tombigbee, the Intracoastal, the 'Cross-Florida and Cape Cod canal projects into such a river basin program.

In view of the generous response of so many transportation authorities to the exposure of non-factual allegations tending to minimize the benefits of waterway transportation, the author's reluctance to give it such wide application as did some of the commentators may seem ungracious. Both Messrs. Cookingham and Marsh seem to take the author to task for not classing the Missouri River as among the most generally beneficial of public improvements. The omission has no great significance. It was merely the author's complete lack of acquaintance with

20. Chief Navigation Consultant, Hoover Commission, Washington, D.C.

the region and ignorance of the adaptability of the river to modern navigation requirements. He does not challenge the validity of their claims, but he is convinced that there are many more economical projects on which to spend public money than there are funds available for spending. The problem would seem to be to select from among many economically justified purposes the uses that will return the greatest benefit to the largest segment of the national public.

Mr. Marsh cites an important factor in holding down the cost of barge transportation, in the remarkable technological advances that have been made in the design of floating equipment and motive power. He recognizes, however, some of the conflicting objectives that tend to confuse the issues of water resource development in the interest of the general public as opposed to the purely local viewpoint.

Mr. Cookingham stresses the essential coordination of water resource development of a great river valley for all purposes, narrowed down to its effect on the Greater Kansas City region. This important area in the nation's economy has recently experienced a most disastrous flood, and the potential benefits of all-purpose river control are well exemplified by its needs.

Mr. Stanley's discussion is a welcome amplification of some of the points it was attempted to make in the paper, and a refutation of some of the widely accepted allegations as to the methods of the Corps of Engineers. He furnishes a clear example of the incremental principle of project justification in the replacement of old structures with new and improved ones. He also calls attention to the ultra-conservative method used by the author in computing transportation savings, and greatly clarifies the expression of the underlying principle of "feeder value" of branch waterways. He finds that competitively depressed rates are uneconomic and prejudicial to the public interest.

Mr. Stanley attributes to the author a basic objection to the principle of imposing tolls on the users of inland waterway transportation. As a matter of fact, the author is not opposed to user charges in principle. He believes that some practical form of collecting tolls will have to be worked out, before the competitive situation among the several modes of transportation is equitably adjusted. He is frankly appalled at the magnitude of the task of finding a workable formula that will not do more harm than good.

Colonel Schull contributes welcome statistical support to the conservative estimating technique of the Army Engineer organization. It may be held that the Florida Intracoastal canal is not the most appropriate choice of projects to demonstrate the broad incidence of waterway benefits. Since a large proportion of its users are owners of yachts, cabin cruisers and other pleasure boats, it may be claimed that they do not comprise a representative cross-section of the national population. However, it can also be argued that they pay a disproportionately large share of income taxes into the Federal Treasury, from whence come the improvement funds. It is worthy of note that the improvement of waterways at the expense of the general public; even the consideration of yachting and pleasure-boating as legitimate commerce in the justification of such waterway projects; is a policy of Congress expressed by statute, and not a just principle originating with the Corps of Engineers.

Mr. Magnuson brings to the discussion a wealth of experience with the provision of small "feeders" to the Intracoastal Waterway system. He finds that they, too, in the main, show a favorable ratio of transportation savings to construction costs, when the continuous water movements they originate or terminate are taken into consideration.

Mr. Carr evidently concurs with the author that the general public has been misled by continuously repeated but carelessly verified misstatements of fact with regard to typical inland waterways. He, too, finds that waterway projects necessarily involve beneficial secondary results to the public in addition to the primary purposes of the improvements.

Mr. Childe's water transportation experience and background, alike in the service of the federal government, as an official of national transportation associations, and as a professional transportation consultant, eminently fit him to comment constructively on the economic aspects of waterway projects. The author has profited many times in past years from his wise and learned counsel, and his contribution to the discussion of this paper is deeply appreciated. Mr. Childe correctly interprets the paper, not as an attempt to vindicate all waterway improvements, but as an effort to explain and defend the methods of the Corps of Engineers from a kind of unwarranted criticism that seems to have flourished for lack of refutation.

Mr. Childe apparently concurs with the author that present competitive conditions among the various transportation agencies, in which some pay their full costs while others receive some form of subsidy, is inequitable. He realizes, however, that under existing regulatory license, the strongly intrenched carriers of a wide variety of commodities could strangle less favored competitors by selective manipulation of rate scales. He appears to agree that some form of rigid rate control based on the cost of performing the service holds out the only hope of equitable adjustment.

Mr. Childe feels that low-cost water transportation has become a vital necessity to the industrial prosperity of the country, and that its public benefits go farther than the mere direct savings in transportation charges to the users measured by the engineers in appraising the economic merits of proposed waterway improvements. He thinks that an excess of caution in estimating public benefits may be a more serious fault than the over-optimism ascribed to the engineers by hostile critics.

Mr. Childe recognizes that the piecemeal approach to water resource development is not a responsibility of the Corps of Engineers, but is inherent in the existing statutes and Congressional procedures of authorization and appropriation. He readily concedes that the nation's transportation system must be coordinated in best interests of the public. In furtherance of that end he believes that all development of transportation media should be subject to review and appraisal by an impartial body within the framework of the Executive Branch of the Government. The Corps of Engineers would be expected to function with its acknowledged efficiency under such a system of over-all control.

From their long experience in the more or less arid Southwest, Colonel Wilson and Mr. Graham are well qualified to attest the advantages of inland water transportation and the stultifying effect of its unavailability to regions to which it is not accessible. They trace the upward trend in volume of the nation's freight burden since 1940, calling attention to the accelerated growth of highway, pipe-line, and waterway traffic in percentage of the total movement. They find a reason for the spread of propaganda adverse to waterways in the desire of the railroads to reverse this trend, and claim that such action is shortsighted and detrimental to the railroads as well as to the public at large, because of the fundamental inability of high-cost carriers to compete with low-cost carriers on an economic basis. They cite the well-known technological advances giving greater dependability to waterway transportation and the characteristic decrease in the cost of such transportation as the volume increases. It is believed that there is merit in these contentions.

In view of his many laudable contributions, not only to the technical literature on transportation, but to the actual construction and administration of some of the most important national river and harbor projects, the author considers Colonel Hall to be the most outstanding authority on water transportation in the country. It is therefore highly gratifying to have him discuss the paper, — "Some Economic Aspects of Waterway Projects," — and highly appropriate that his comments should be the most critical among those contributed. As to the report of the Task Committee of Engineers' Joint Council, criticized on page 318-15 of the paper, the only passage to which the author took exception attributed the growth of inland waterway traffic in recent years to the absence of charges for the use of the waterways. There had been made available to the Council by the Chief of Engineers, when this report was issued, a tabulation of the economic results of improvement of the principal inland waterways, showing that annual savings in transportation charges so far exceeded annual costs of improvement as to leave ample margin for the attraction of traffic, even if user charges had been imposed. Viewed by the author in retrospect, in the light of their other findings, it appears well within the province of the Councils' Task Committee to question the conservatism of the methods employed in computing the benefits in this tabulation. The author regrets having ascribed other causes for what now appears to have been a reasonable difference of opinion.

As to the validity of justifying additions or replacements to waterway projects by the incremental method, the author still maintains that the principle is sound. If, in the example cited by Colonel Hall, the commerce expected to originate in western Iowa and eastern Nebraska had been credited only with the savings over and above those made available by the Upper Mississippi, the Missouri River project would have been entitled to credit for those incremental savings even though that particular block of commerce were thus diverted from the Upper Mississippi improvement.

Colonel Hall was probably justified in ascribing a pessimistic attitude to the author with respect to the eventual regulation of transportation rates to reflect carrier service costs. Many years of observation

of the decisions of the regulatory commissions would seem to offer but little encouragement. However, the author does not actually maintain so negative an outlook into the future, in view of the obvious advantages of a cost basis of rate making such as advocated by Colonel Hall, to the public interest.

Mr. Davis's discussion brings out some refreshing viewpoints in the analogies between inland waterways and improved tidal estuaries and harbors. He calls attention to absence of demand for reimbursement of the Treasury for federal "subsidies" on the part of users of harbor improvements, although many of these users clamor for tolls on inland waterways. He likewise agrees that engineers charged with the development of rivers and harbors have been unduly tolerant of invalid and nonfactual criticisms of their methods and procedures, thus permitting the general public to acquire a distorted conception of some economic aspects of waterway projects.

As stated in the beginning, this paper did not undertake to deal with the more valid strictures on the waterways program and its administration by the Corps of Engineers. It was felt that these had been given more than adequate circulation by the critics and their press agents. If opponents had been content to rest their case on valid criticisms alone there would have been no occasion to take up the cudgels in behalf of the procedures of the Corps of Engineers.

One point must be made clear, even at the risk of seeming to repudiate the support of some of the discussions. Several of these went considerably farther than the author is prepared to go in extolling the economic virtues of practically all federal waterway projects. It is felt that the indescriminate support of any and all proposals for improvements for navigation militates against a sound program in the general public interest that must guide the Corps of Engineers in its evaluation of waterway projects.